



Exploring Science and English Language Development: Implications for Professional Learning

A conference hosted by the Exploratorium's Institute for Inquiry, January 2015

The fields of science learning and language development are at a pivotal moment where they are being challenged by emerging ideas and new instructional models that have profound implications for practice and research. Language acquisition has been increasingly framed by theories that are socially oriented and rooted in the learners' use of language through interactions, rather than through their mastery of structures and forms. Science instruction has come to be seen as expanding beyond the transmission of content knowledge to include the scientific, linguistic, social, and cultural practices that learners use when engaging with phenomena and making meaning. New research is revealing the potential for science to serve as a powerful context for language development, and examples of teaching practices that reflect this current thinking are becoming more common. Still, both practitioners and researchers are faced with the challenge of understanding the supports that teachers, schools, and districts require to further this work.

It is against this backdrop that the Exploratorium convened a group of fifty prominent researchers and practitioners to share their varied and complementary perspectives on the relationship between language development and science learning, and to address the opportunities and challenges that educators and designers of teacher professional learning face when viewing science as a context for language development. What made the conference unique was the breadth of representation across different fields and educational systems—classroom practice, educational and applied linguistics, policy, teacher education, professional learning, science education, educational research, and district reform. The conference used the following questions to focus the diverse expertise of participants on a shared set of issues:

What do teachers need to understand about learning science, learning language in the context of science, and pedagogy that would support both?

What design principles can guide the creation of professional learning experiences that enable teachers to make science a good context for language development?

What research questions can support future efforts to create professional learning experiences for science and language development?

Following the structure of the conference sessions, this synthesis documents the primary themes and recommendations that emerged, and traces their implications across the disciplines and contexts in which they surfaced and can be further advanced.

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Why Is Science a Good Context for Language Development?

Two plenary presentations provided context for conference case studies and working groups by exploring fundamental conceptions of science learning and language development.

Plenary Presentations

Science Learning and Language Learners

Helen Quinn, Professor Emerita of Physics, SLAC National Accelerator Laboratory, Stanford University, and Committee Chair for Conceptual Framework for New K–12 Science Education Standards



“Previously in science education...we kind of expected kids to learn science by themselves, but they need support in doing it. They are going to be using language, they are going to be asking questions, they are going to be talking to one another to figure out the answers to those questions. So this notion of three-dimensional science learning is discourse-intensive science learning.”

The three dimensions of science learning that frame the Next Generation Science Standards (science practices, disciplinary core ideas, and crosscutting concepts) necessitate the use of language to make sense of science.

- Learners must communicate in various modalities when they are engaging in science practices, creating multiple **opportunities for language development**.
- Science practices engage learners in communication about science ideas that are **embedded in phenomena**.
- Three-dimensional science learning is **discourse-intensive science learning** because it involves using language to ask questions and communicate with others to develop explanations that answer those questions.
- Crosscutting concepts give learners **tools for asking questions** that allow them to investigate any problem or phenomenon in science.
- Teachers can make science learning in their classrooms provide opportunities for language development by managing the discourse so that it is **inclusive and supportive** of students at **levels appropriate to their growth**.

How Science Understanding Develops

- Multiple opportunities to hear and use science ideas and practices
- Rich contexts (phenomena and materials) create desire and opportunity to engage and contribute
- Appropriate supports
- Acceptance of flawed (non-scientific) language and incomplete ideas

How Language Develops

- Multiple opportunities to hear and use language
- Rich contexts (experiences) create desire and opportunity to engage and contribute
- Appropriate supports
- Acceptance of flawed language, while still supporting language development

Why Is Science a Good Context for Language Development?

Doing Science with Language: Acquiring English through Participation

Guadalupe Valdés, Bonnie Katz Tenenbaum Professor of Education, Stanford University

Sarah Capitelli, Assistant Professor, Teacher Education, University of San Francisco



"In this other tradition of looking at the language, what you acquire is the ability to use the language... to do things with language. I don't want to know about the past progressive, I want to know whether you can insult someone, whether you can buy and sell, whether you can bargain. I want to know what you can do with language. Give me a function. Can you argue? Can you defend a position? And can you do it orally and can you do it in writing? That's what it means to do something with language, as opposed to knowing a structure."

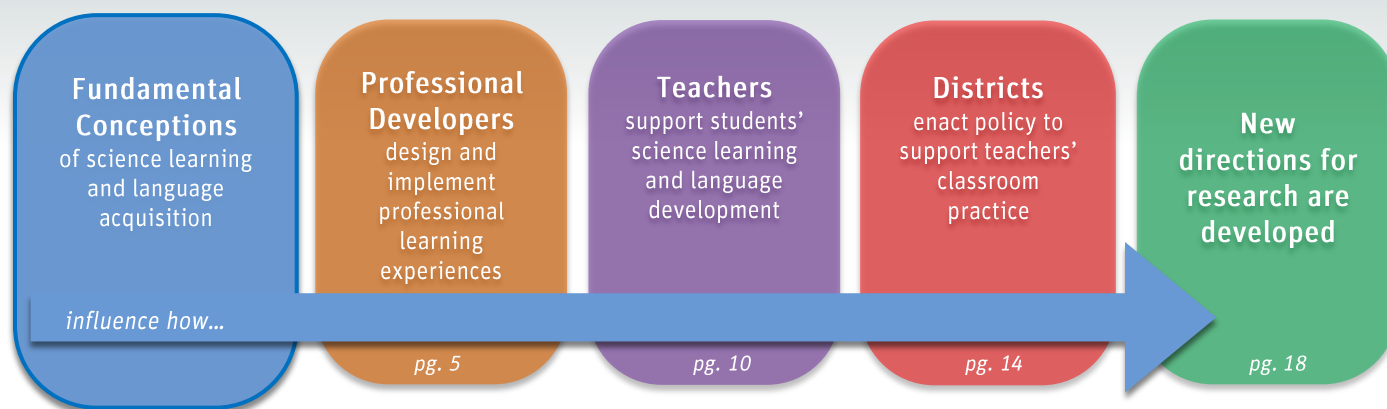
New theories of language acquisition and examples of students engaged in productive uses of language reveal how and why science can be a good context for language development.

- Traditional views of language acquisition focus on language as a set of words and structural forms. This is a “bits and pieces” view that relies on individually-, rather than socially-oriented, cognitive processes.
- Current research and practice about language acquisition considers language **to be acquired through use** in a social context for particular purposes.
- Scientific practices create **affordances for participation in language-rich experiences** by mirroring real science, by engaging students in activities precipitated by their own interests, and by giving students opportunities to observe, raise questions, make predictions, and create conceptual models.
- Subject matter learning and science learning in particular create situations where language is used for various purposes, including developing and sharing ideas with other people.
- Current goals for language development focus on growing the ability of second language speakers **to do things with language**, regardless of whether they sound like a native speaker. The linguistic repertoire grows through use; however, we should not expect English language learners to acquire the same proficiency as native English speakers.

Socially-oriented language instruction:

- Is grounded in language socialization (usage-based theories of language acquisition)
- Engages caretakers and other competent speakers to:
 - invite students to attend to the world that surrounds them
 - narrate experiences
 - describe the world
 - encourage questions and provide answers
 - allow students to engage with less-than-perfect language
- Emphasizes intent participation that involves students attending to, observing, and learning cues

Why Is Science a Good Context for Language Development?



What fundamental conceptions of science learning and language acquisition are necessary in order for science to be used as a context for language development?

Science Learning

- The three dimensions of science learning put forward by the Next Generation Science Standards (NGSS) and Conceptual Framework for K–12 Science Standards emphasize that science is best learned through engaging in science practices to investigate disciplinary core ideas and recognize crosscutting concepts.
- Constructivist and sociocultural views of learning are essential elements of inquiry-based science.
- There is incredible value in drawing on learners' sense of wonder and curiosity. Inquiry-based science accomplishes this by presenting students with engaging phenomena that can be observed and explored in different ways over time.

Language Acquisition

- Language is acquired through use and through interaction with others.
- Experiences that are personally meaningful for students motivate them to use language to communicate their thinking.
- The linguistic repertoire grows through use; however, we should not expect English language learners to acquire the same proficiency as native English speakers.
- Emerging language is not a barrier to understanding science. When supported appropriately, English language learners can use less-than-perfect English and still comprehend and communicate science ideas.

Science and Language Learning

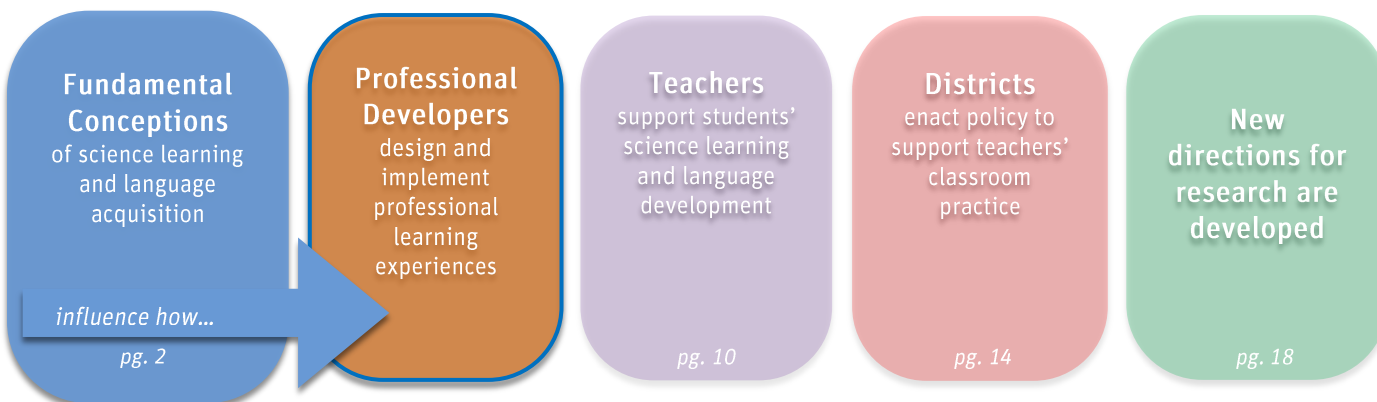
- Science and language can be thought of as intertwined and interdependent.
- NGSS-oriented science can be a good context for developing language because of the many affordances it provides for the meaningful use of language. However, the discourse needs to be managed to be inclusive, with various levels of support for language development offered as needed.
- The NGSS rely on the affordances that language provides for making meaning of phenomena, and not merely on objects or phenomena in and of themselves.
- Understanding why science is a good context for language development includes:
 - Recognizing that engagement with ideas emerges from interacting with science phenomena
 - Leveraging the use of language across all modalities: reading, writing, speaking, and listening
 - Perceiving and taking advantage of the opportunities to develop language that are inherent in the process of learning and sharing science ideas
 - Recognizing and providing support for the language demands that accompany the different ways that teachers and students communicate about science (e.g., questioning, negotiating, analyzing, debating, etc.)

Educational Equity

- Values like educational equity shape teaching practice and classroom culture and impact all students' learning.
- Equity does not mean sameness. It involves recognizing and addressing students' different capabilities and needs so they can be supported to fully participate in rigorous, intellectually engaging, language-intensive work.
- Designing for educational equity requires that teachers understand and honor their students' ideas and capabilities, and acknowledge their value and help them succeed as individuals and as a group.

Comparing Approaches to Professional Learning

Three professional learning programs presented case studies that showcased the evolution of their work with teachers. In spite of their varying contexts and differences in the design of professional learning experiences, these programs shared similar ideas about what teachers need to know and be able to do, as well as similar trajectories of growth in their understanding of how to design professional learning experiences that support language development in the context of science.



Professional Learning Case Studies

Case Study #1: We Are Talking to Learn Science: Finding the Right Fit

Therese Shanahan, Science Academic Coordinator, University of California, Irvine

Lauren Shea, Director of Education, Outreach, and Diversity, University of California, Irvine



Therese Shanahan



Lauren Shea

This project provided K–5 teachers with professional development focused on learning and teaching math and science.

- The project's design principles for professional learning included:
 - Teachers' use of inquiry-based pedagogy to learn the grade level content that they would teach
 - Teachers' participation in professional learning communities to solve problems and discuss district context
- Each year, the project refined the way that they supported teachers to help students engage in discourse.
 - Science lessons were revised to include more explicit support for talk strategies
 - Professional development sessions were modified to reflect this emphasis on discourse
- Teachers reported an increase in the amount of oral language that occurred in classrooms, along with increases in teachers' and students' understanding of science content.
- Research indicated that teachers developed more nuanced perceptions of how student talk increased learning of science and engagement in all academic content.

"All of these projects traced a path: We thought we knew what we were doing and realized, as we started working with teachers and empowering teachers and trying to give them some agency, that in fact we needed to change how we were thinking about our model. We need professional development that looks at new contexts, new ways of doing professional development, and brings together new players in our professional development."

– Cory Buxton, Professor of Education, University of Georgia

Case Study #2: A Blended Science and ELD Lesson Design

Susan Gomez Zwiep, Associate Professor, Science Education, California State University, Long Beach



"We began to see a protocol for how to think about rigorous scientific experience as an authentic place for language to happen. If you are going to do science, using the practices, you are going to use language."

This project developed and refined a science program to provide access to rigorous science learning for English language learners in a district that had previously only provided access to English language proficient students.

- The design principles for professional learning that emerged over the course of the project capitalized on the expertise of teachers. For example:
 - Teachers' expertise includes the ability to interpret and respond to students' learning needs
 - Teachers bring valuable multiple disciplinary perspectives that help to shape the work of science supporting language development
- The project developed a protocol for teachers that helped them consider science goals and language needs so they could create rigorous science experiences for students that were also natural places for language to happen.

Case Study #3: Learning Language within the Context of Science: Creating a Professional Development Approach

Lynn Rankin, Director, Institute for Inquiry, Exploratorium

Paula Hooper, Senior Science Educator and Learning Research Scientist, Exploratorium

Sarah Capitelli, Assistant Professor, Teacher Education, University of San Francisco

This project supported language development in the context of science by providing professional learning and classroom resources across a district with a high percentage of English language learners.

- The project's principles for professional learning design included:
 - Engaging teachers as learners of the same principles of inquiry-based science they were to implement with students
 - Illuminating how inquiry can create a content-rich and language-rich environment with affordances for English language development
 - Attending to the social and cultural dimensions of language development
 - Incorporating science writing and science talk as pedagogical strategies for science to support language development
- The project developed a conceptual framework that teachers could use to adapt their lesson planning and classroom practice to take advantage of the overlap between science and language in their classroom.



"What really struck me is that the people doing these research projects, these case studies, learned as much about PD and about the teachers' lives as the teachers did about some of the content areas, and I thought that was really wonderful."

– Chris Faltis, Professor, Co-Director of Teacher Education,
Dolly and David Fiddymant Chair in Teacher Education,
University of California, Davis

Common Themes in the Case Studies

- Each of the professional learning cases came to conclusions about the significant role of science discourse in blending students' science learning with language. The projects each began with a general awareness of the importance of oral language for language development. After observing how the integration of discourse into classroom inquiry experiences furthered students' language acquisition, the teams began to center their professional learning experiences on how teachers can create and enrich opportunities for talk throughout science instruction. This approach resonated with fundamental ideas about the place of discourse in NGSS-based science and language acquisition that were conveyed in the plenary presentations. Additionally, there was a recognition that supports are required for students, particularly English language learners, to fully engage in science discourse and make meaning from the experience.
- All of the projects drew upon inquiry-based NGSS-aligned approaches, because the use of language demanded by the scientific practices has strong conceptual connections to theories of language acquisition central to their program designs. Taken together, the three dimensions of the NGSS (scientific practices, disciplinary core ideas, and crosscutting concepts) create opportunities for the meaningful use of discourse, writing, reading, and listening.
- The case studies shared several trends in the design and development of professional learning.
 - There was a realization that collaboration with teachers was key to the development of effective professional learning. It was pivotal to consult teachers on how to shape projects to respond to their district and school contexts.
 - It was critical to include a process of iteration and refinement of designs for professional learning based on new knowledge about the teachers' contexts and their experiences within each round of professional development.
 - There was a shared recognition that the teams who developed professional learning experiences benefitted from connecting expertise across the fields of language acquisition, ELD, and science education. There was an acknowledgment that representatives of these areas need time and effort to learn to work together.
- Because lesson plans and materials that support language development in the context of inquiry-based science are not easily available at this time, each project had to find a way to deal with this need. The projects took different approaches to developing and using existing curriculum. In two cases, science curriculum units were designed by the professional learning team and provided to teachers, who were then supported in learning to modify the units in order to help students meet the language demands of the lessons. A third case used a lesson study model, in which teachers developed the units with support from science educators and language learning experts.
- All three projects based their approaches to science on existing models for inquiry, drawing from different sources in doing so. Because of the affordances it provides for language development, an inquiry-based approach was at the core of all three programs.
- In designing and refining professional learning experiences, all three projects recognized the importance of being responsive to the context in which they operated. In addition to teachers' needs, different administrative and policy-based requirements factored into negotiations for project focus, and led to different programmatic characteristics.

“We get very comfortable thinking that as experts in professional development we know best practices that have been around for years and we can just do them. I think this work should cause us all to question what we think we know about where professional development happens and what it looks like, and we need some new settings and contexts to think about it. I think this is the group to push the field, and not just for science. We can serve as a model for what a lot of other people need to be doing as well.”

– Cory Buxton, Professor of Education, University of Georgia

Professional Learning Design Recommendations

The following general recommendations, which were derived from the case study presentations and conference working groups, focus on the ideas, values and practices that can guide the design of professional learning that supports English language development in the context of science.

- **Promote teaching as a practice of inquiry into teaching and learning.** Build teachers’ confidence through trial-and-error, and encourage them to be active designers and re-designers of experiences in their own classroom. Involve and support teachers in creating case studies of their own teaching practice. Cultivate a posture towards teaching that treats it as something you can analyze and think about and learn to do better.
- **Acknowledge that teachers need protected learning spaces and support to take risks** as they’re developing an understanding of new pedagogies. This includes time and allowances for experimentation. Make professional development a safe place where teachers can have sustained, shared learning experiences. Develop relationships in which the teachers feel valued and secure and able to ask collaborators (mentors or peers) for guidance.
- **Support teachers as learners and agents of change.** Engage teachers in the experience of learning science content as their own students would, so that they can identify themselves as science learners. Provide them with the opportunity to reflect on their own learning experiences so that they can be an ongoing part of how they shape their classroom practice. Communicate the idea that making progress in shifting classroom practice happens incrementally and over time.
- **View teaching as facilitating learning.** Move away from the approach that treats teaching as telling. Develop an attitude to teaching that prioritizes facilitation, supporting students to take ownership of their own learning.
- **Design professional learning that is collaborative and reflective.**
 - Provide teachers with access to science and language experts, science educators, and ELD experts, within and outside of the school/district community.
 - Foster leadership and collaboration skills over time so that teachers can be active members of an ongoing professional learning community with other teachers and professional learning providers.
 - Design an approach to professional learning that incorporates the distributed expertise and voice of professional learning providers and teachers.
 - Give teachers the opportunity to review students’ work and the expression of their understanding—both as formative assessment and insight into instructional decisions that can be made to further student learning and improve teaching.
 - Devote time to lesson planning in teams, allowing teachers to share and collectively analyze their students’ learning experiences to better understand and inform each other’s lesson designs.

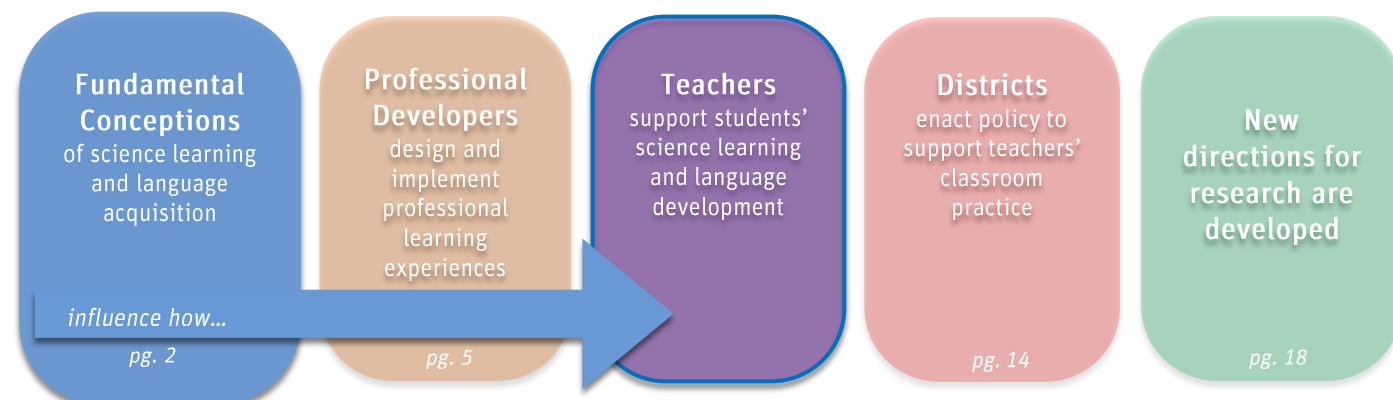
- **Account for the need to be flexible and context-dependent.**
 - Be responsive to teachers' needs, which can vary by grade, background, and degree of experience. Professional learning should be personalized and differentiated—you need to know your learners.
 - Ground teachers' work in their curriculum and provide adequate support and time for shifting, adopting, or creating new resources. Look for opportunities to integrate science and language in teachers' existing curricula.
 - Provide principals and administrators with professional learning experiences so they can support teachers as they experiment with new and innovative teaching practices.
 - Develop a culture that respects that experimentation and change take time.
 - Support teachers to identify what data and evidence they need to collect so they can communicate what is working and substantiate to administrators that they are on a productive course.
 - Provide ongoing professional learning experiences that build on each other over the long term, and are capable of evolving in response to teachers' needs.
- **Address teachers' foundational skills and knowledge.**
 - Ground professional learning in a deep understanding of science and language pedagogy, not an assortment of disconnected or decontextualized techniques and classroom activities.
 - Provide teachers with direct experiences of both science learning and language use as a starting point.
 - Develop a conceptual understanding of how science and language learning reinforce each other.
 - Provide videos that can be used as case studies of what teaching science to language learners looks like in a variety of classrooms.
- **Promote classroom practices that:**
 - Engage students in discourse that is based on first hand experiences with science phenomena
 - Pay attention to individual and group dynamics and ensure equity and engagement of all learners
 - Encourage more than "one right way" to learn and communicate meaning
 - Are explicit about what the important learning goals are
 - Make students' thinking visible in different modalities (e.g., listening, speaking, reading, writing)

"To me it is really interesting that we have these two worlds. There is science learning and there is language learning. What I love about this conference today is that we are really looking for ways to pull those things together and to show how they work together. So I am encouraged, even though there are lots of things we have to change. We can do better than what is out there, and I am really jazzed about this."

– Chris Faltis, Professor, Co-Director of Teacher Education,
Dolly and David Fiddymont Chair in Teacher Education,
University of California, Davis

Exploring Classroom Cases of Science as a Context for English Language Development

Four elementary teachers presented their classroom practice as case studies. Despite their varying contexts, the cases all illustrated how science can support the meaningful use of language.



Classroom Case Studies



Jennifer McDonald

Case Study #1: Science and ELD: Providing a Context for English Language Development

Gennifer McDonald, 2nd/3rd-Grade Teacher, Sonoma Valley Unified School District

Gennifer McDonald's classroom is made up of 80% English language learners (ELLs). She uses a carefully planned and scaffolded combination of inquiry-based experiences, discourse, and writing to create a language-rich, science-rich classroom culture.

- **Effective integration of inquiry-based science and ELD is student-centered.** *"It was all about the students. It was not what I was giving them, it was what they were doing that was really giving me something, and we were working and learning together, based on students' interests and what they needed—their language needs, but their science needs as well."*
- **A model of exploration, observation, investigation, and explanation moves through all of the facets of the inquiry process.** *"I give them a phenomenon to explore so that we can talk about it, we can question, we can wonder, we can think... And then when they get to question and investigate they can really make meaning from the science concept or phenomenon, but also explain it to their peers. It is during those processes where all the rich language comes out."*
- **Science lessons and their language supports are strategically planned to work together.** *"As a teacher, I have to really think about how to plan learning opportunities in science, and plan all the learning opportunities to support language... I have been trying for many years, putting in mini-lessons of language that I feel are important for them to acquire the science, and talk about it, and write about it. There is always a combination of those three things: some sort of experience, some sort of writing, and some sort of talking."*
- **The role of the teacher is to facilitate.** *"I see myself during all of this not as a teacher, but more of a facilitator of the learning of science and the learning of language. I am a constant questioner—I call it 'rapid-fire questioning.' I have different types of questions that I ask the students to get them to use the language that I'm looking for and really understand the meaning that they're making from the science."*
- **Participating in a professional learning community is key.** *"I definitely didn't get to this point on my own. I got here through professional development with my school site and with my district and with my colleagues. I wouldn't be where I am without the sustained training and support from administration, from my team, from my co-creators, my professional development group."*



Emily Miller

Case Study #2: Supporting English Language Learners in Sense-Making During Science

Emily Miller, Elementary ESL/Bilingual Resource Teacher, Madison Metropolitan School District, University of Wisconsin, Madison

An ESL and Bilingual Resource Teacher for elementary grades, Emily Miller uses the science practice of modeling to evoke and develop students' understanding of science concepts, stimulate active participation in discourse, and address issues of equity. Her work is grounded in the belief that all students should be prepared to make becoming a scientist a real possibility in their lives.

- **The science practices of the NGSS support science learning and English language development.** *"The practices are language-intensive and they are where language and science understanding are built together...modeling can serve as the key practice where every other practice comes into play."*
- **Modeling is a student-centered language scaffold.** When students are asked to represent their understanding through models they naturally draw on the language and types of expression that they require and feel comfortable with. *"The scaffold is built by [the student]. He made it, and the language that he needs to express, he made himself, so it's a perfect scaffold."*
- **Modeling provides for authentic and meaningful discourse around multiple science ideas.** *"If I can have my idea understood by others I am motivated to produce language. And the collaborative sense-making that occurs through the practices can only occur if more than one idea is on the table. I want the students to do the work of really understanding each other, even if the idea is different from what theirs is... I want to incorporate that notion of hard work, that talking together is hard work."*
- **The practice of modeling can promote equity by eliciting and valuing students' ideas.** *"When students are making sense of phenomena, modeling can serve as a way towards equity in conversation and sense-making, but the phenomena have to be place-based and engaging... I have to design for my ELLs to be initiators, as well as responders, of meaning-making in groups. This is really tough because we spend a lot of time making sure our ELLs are listening but don't have the kids who are not ELLs, who are L1, spend a lot of time trying to understand our ELLs. I want to underline that. As long as that's not happening we're missing a lot."*



Jessie Auger



Naomi Mulvihill

Case Study #3: An Interdisciplinary Approach to Supporting Language through Science

Jessie Auger, Elementary Bilingual Teacher, Boston Public Schools

Naomi Mulvihill, Elementary Bilingual Teacher, Boston Public Schools

Naomi Mulvihill and Jessie Auger, both dual language, Spanish-immersion teachers, have developed sequential, year-long, inquiry-based curricula to provide their Kindergarten and 1st-grade students with rich, interdisciplinary experiences of science phenomena that also encourage English language development.

- The development of a theme over the course of the school year, from the first day of class until the last, creates **extended opportunities for students to use language** throughout related experiments and in relationship to ideas of increasing complexity. *"The science content is really the backbone of our literacy work with our students. What we want to provide for our students is a coherent set of contexts for simultaneous science and language learning."*
- **Students' direct experiences are a catalyst for their science learning and language use**, motivating them to communicate their curiosity, confusion, and wonder. The themes for exploration—in this instance, birds and oceans—were chosen so that students could observe phenomena in their natural environment.
- **Students' work spans many different types of activities** including group observation and discussion, experimentation, journaling, investigation planning, field trips, presentations, art projects, and correspondence with scientists and other experts in the field. Throughout these rich experiences, students repeatedly engage in multiple modes of communication: reading, writing (including drawing), speaking and listening in many different settings. *"Over the years of developing this we have acquired a really wide range of resources, from simple picture books and posters to really sophisticated texts, websites, diagrams, and videos. We also facilitate student-made resources."*

What do teachers need to be able to do in their classroom practice in order to support language development in the context of science?

The following general recommendations were derived from the case study presentations and conference working groups. They focus on the ideas, values, and practices that can guide the design of professional learning to support English language development in the context of science.

Science Learning and Teaching

- Science taught in inquiry-oriented ways that:
 - Appeal to students' sense of wonder
 - Incorporate the science practices to investigate phenomena, which leads to developing an understanding of disciplinary core ideas and crosscutting concepts
 - Explore ideas through a rich variety of activities inside and outside of the classroom (e.g., investigations, discussions, drawing, reading, presenting, diagramming, journaling, project work, field trips, etc.)
 - Place the focus on students and increase their control over their own learning
- Science practices can provide engagement that gives access for all students to participate in learning science. The science practice of developing and using models is particularly important because it provides an opportunity for teachers to elicit and value every student's ideas. Modeling can also be a valuable formative assessment tool for teachers as individual students will naturally represent their ideas through concepts and language that are accessible to them.
- Teachers need to encourage productive attitudes (e.g., enthusiasm, curiosity, self-reliance) toward science.
- Teachers need to be active and reflective learners of science themselves.

Language Acquisition

- Teachers need to be able to recognize and respond to what all students are capable of doing with language, regardless of their level of English language proficiency.
- Teachers need to create a classroom culture where:
 - A variety of discourse is valued and nurtured
 - Students feel comfortable talking and sharing their ideas in multiple forms
 - Students are supported and encouraged to listen to, and learn from, each other's ideas
- Valuing and eliciting multiple kinds of discourse requires teachers to hone their facilitation skills so they can encourage and manage discourse strategies.
- Science can be a focal point as teachers engage students in talking, reading, and writing. In the process, teachers can make connections to relevant aspects of literacy and math, thus blending elements of NGSS and CCSS in their practice.

Science and Language Learning

- Teachers need to develop a pedagogy that engages all students in active use of language to wonder, notice, investigate, and explain. These uses of language are particularly beneficial for English language learners.
- Oral discourse is key to developing literacy skills both within science and across subject matter. In K–5 classrooms, opportunities can be created for students to work on speaking and listening to each other's science ideas as support for reading and writing that benefits learning science.
- As students engage in science practices—such as asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations, engaging in argument from evidence, and obtaining, evaluating, and communicating information—they use language to communicate their ideas, discoveries, and observations. This makes the science practices valuable resources for supporting the use of language while students are learning science.
- Teachers need to recognize the language demands created by using the science practices and provide appropriate scaffolding for students to meet these demands. This involves an understanding that scaffolding provides a special kind of temporary support that assists students in engaging in meaningful and challenging tasks in order to move skills and understanding to new levels. The goal, over time, is to foster students to become more independent learners as they transfer these skills and understandings to new situations.

Educational Equity

- Equity involves guaranteeing the opportunity for all students to engage in intellectually complex science, even though they may require different kinds of language supports for working with the same content. The recognition that students are able to communicate powerful ideas with less-than-perfect language is an important aspect of inclusion. Emphasis should be placed on making meaning in a common effort to build understanding of phenomena, rather than on correcting the use of “flawed language.”
- In the NGSS, inquiry-based science is refined and deepened by the explicit definition of eight science and engineering practices, which have major implications for non-dominant groups (NGSS Appendix), especially English language learners. Engaging in these practices, despite the challenges they pose, can provide ELLs with rich language and science learning experiences, if teachers provide the necessary support for them to participate.
- Teachers need to understand, respect, and value the varying cultural and social contexts that factor into students’ learning. Accessing students’ backgrounds of prior knowledge and experience can provide teachers with a foundation for encouraging discourse, new paths into content knowledge, and cues for structuring peer-to-peer work that supports participation.

“I thought the teacher cases were really compelling...they are extraordinary people doing extraordinary work, articulating their work clearly, and engaged in an inquiry about the work. To me that is the center point of an effort...these are “leading teachers” in the same way you would have a leading doctor or leading surgeon or leading musician, someone leading in their field. They are people who are concerned, very much, about improving their own practice, just as a doctor or surgeon would be concerned about improving their practice, but they are also concerned about sharing that practice with others, bringing the knowledge of others into their practice.”

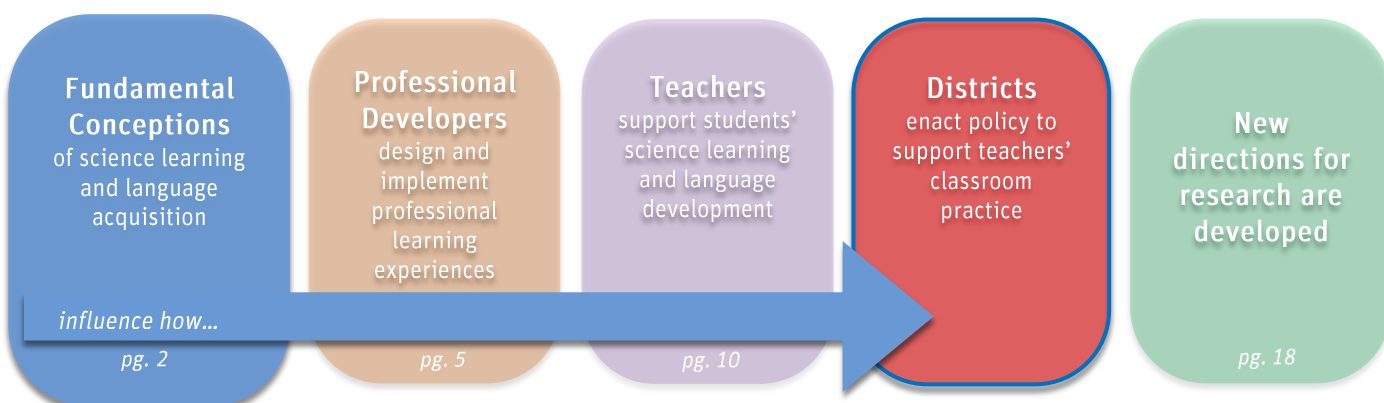
– Mark St. John
President, Inverness Research



Jennifer McDonald facilitating small group discussions in her classroom

District Contexts and National Perspectives

A series of presentations on how policy frameworks, standards, and district reforms surround and shape efforts to support English language development in the context of science.



National Policy Perspective

Okhee Lee, Professor of Childhood Education, New York University



This session included a historical overview of shifts in national standards in science education to provide a context for analyzing current views of science and English language development reflected in the Framework for K–12 Science Education and the Next Generation Science Standards (NGSS).

A productive goal would be to create policy contexts that support the synergy of science and language, where rich language use and rigorous science learning support each other.

Key points

- Reform can be slow to take root, and waves of reform can last for decades, developing organically over time.
- Understanding where new standards fully replace, partially replace, or build upon previous standards is not always straightforward.
- The NGSS has not been adopted universally, and speaking to different audiences about science reform requires an understanding of their context.

Distinguishing features of the Framework and NGSS

- The NGSS outlines and blends three dimensions of science learning—science and engineering practices, crosscutting concepts, and disciplinary core ideas—without privileging one above the others.
- The NGSS has refined and deepened its definition of inquiry to include the science and engineering practices, and treats them as areas where students engage in the intensive use of language.
- Engineering has a central position in the NGSS and involves designing solutions in contexts that are local and relevant to students.
- Rather than considering modeling as a process of literally representing phenomena, the NGSS conceives of it as a way to conceptualize an explanation.
- In the NGSS, rich language use and rigorous science learning are seen as supporting each other.
- One of the unique features of the NGSS is its attention to diversity.

NGSS as a support for student diversity

Central position of engineering

- Designing solutions to problems in local contexts relevant to students' lives and futures

Explicitness of crosscutting concepts

- Expected of all students (not just “gifted,” “honors,” or “advanced” students)

Focus on science and engineering practices

- Refines and deepens science inquiry as broadly defined in previous documents, and relates to the practices scientists do

Three-dimensional learning as the keystone of NGSS

- Local contexts that capitalize on students' everyday language and experience

District Case Studies

The districts that presented case studies shared their strategies for creating supportive contexts for science-rich, language-rich classrooms. While their circumstances differed (a semi-rural and an urban district), they expressed similar values and priorities related to the infrastructures necessary to support teachers to thrive. Both districts have strong visions that promote equity, which means providing access to science as a critical component for the success of all students.

Case Study #1: Sonoma Valley Unified School District

Louann Carlomagno, Superintendent, and Maite Iturri, Principal of El Verano School/SVUSD Project Director

The SVUSD is a semi-rural district with 11 elementary and secondary schools, and 4,600 students, including five K–5 schools with 90 teachers and 1,800 students. The SVUSD partnered with the Exploratorium to develop an approach to teacher professional learning that supports language development in the context of science.



Louann Carlomagno



Maite Iturri

“We have been co-creators in this whole process of professional learning and have really felt like our work has been valued, and there has been this level of collaboration.”

Challenges to science instruction in the SVUSD

- The pressure for the district to focus on math and English language arts under the No Child Left Behind Act drew emphasis away from science.
- The district has a high percentage of English language learners and high-needs students.

Infrastructure to support change

- There is a commitment from district leadership, principals, and teachers to improve science from the inside, while drawing on outside support and expertise.
- Access to science resources for the classroom was key—hands-on kits, science units, and a program coordinator dedicated to administration of the program.
- Professional development for science has been ongoing and aligned with other district priorities, such as Common Core implementation.

Professional development to shift practice and build leadership

- All teachers have participated in the Exploratorium’s professional learning program that supports language development in the context of science.
- Professional learning experiences have been ongoing, including summer workshops for foundational learning and academic year follow-ups focusing on classroom implementation.
- The length of the program—initiated in 2008—has allowed ideas and practices to permeate the district culture and to evolve as they were taken up by teachers over time.
- It was pivotal for teachers to have their own experiences as science learners, and advantageous to situate these learning experiences in an informal learning environment like the Exploratorium.
- Teachers progressed from recognizing the advantages of science for encouraging their students to talk more, to being able to design mini-lessons that leveraged students’ increase in expression for developing particular language skills.
- Teacher leadership and reflections were supported by outside evaluators and researchers.

Case Study #2: Oakland Unified School District

Maria Santos, Deputy Superintendent, and Claudio Vargas B., Elementary Science Coordinator

The OUSD is an urban district with over 100 elementary and secondary schools, approximately 2,000 teachers and 46,000 students. OUSD has been involved in multiple collaborations with organizations to support their science professional development, including the Lawrence Hall of Science and the Exploratorium.



Claudio Vargas B.

The process of transforming the district approach to science ELD was focused on three areas:

1) Examining policy, research, and practice

- As much as policy can influence practice, the district also considers how shifts in classroom practice can shape new policy. Teachers and the community engaged in designing the district strategic plan, which includes a focus on STEM and NGSS.
- The integration of ELD with literacy and science has expanded to emphasize integrating ELD and content in all disciplinary areas.
- Policy changes have included a requirement for a minimum number of minutes for science at the K–5 level and a student-led action research project to establish graduation requirements.



Maria Santos

“Everything we do is framed to hone our understanding of what kids are understanding—how do we actually listen to students and understand the sense-making.”

2) Developing capacity through leadership and teacher professional learning

- Collaborative working groups of teachers have been key to breaking from scripted curriculum and applying teachers’ expertise to the process of instructional design.
- Along with teachers, curriculum and content specialists, principals, principal supervisors, etc. also engage in professional learning experiences with hands-on science and instructional rounds to connect with what is happening in classrooms.
- Extensive professional development across the district has created a strong community of practice and productive communication between teachers and leadership.
- A subset of “trailblazer” schools with a STEM focus have emerged to engage in additional professional development, test new curriculum, and refine resources for others.

3) Focusing on a core of curriculum, instruction, and assessment

- OUSD adopted FOSS kits for their curriculum and focused on academic discussions and science notebooks as instructional strategies to address literacy and ELD within the science curriculum. Focus is placed on writing and talking to learn science.
- The ELA and science departments addressed assessment in a novel way by collaborating with teachers to co-construct a science writing task to serve for formative and summative assessment.
- The district has developed a learning frame to represent the coordination of language and making sense of science phenomena. This model engages students in several forms of interaction with content: “Do It, Talk It, Read It, Write It, Feel It, Model It.”

What conditions, values, and practices in district contexts can support development of professional learning that enables science to be a context for language development?

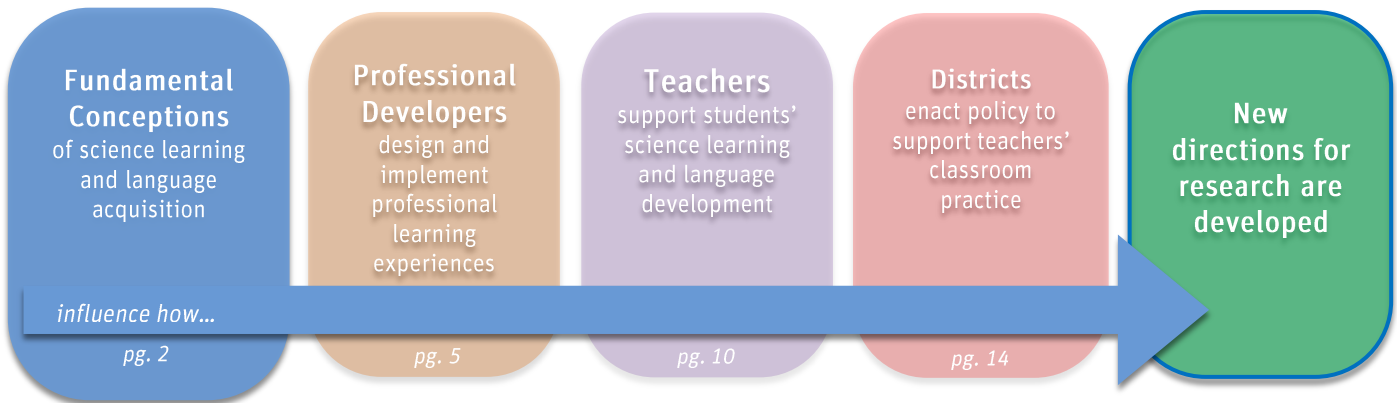
Ideas emerged from all the sessions about the need for systemic transformations that can create the necessary conditions and support for teachers to view language development and the use of language as integral parts of building content understanding, particularly in science.

- **Systemic change requires a clear and coherent vision for science and language** from district leadership, and communication and coordination between district, school leadership, and teachers.
 - Change needs to be driven from inside the system but take advantage of outside expertise for support. Being flexible to take advantage of new thinking and opportunities that emerge is an important ingredient as a catalyst for change.
 - New initiatives need to take teacher agency into consideration. Are teachers being invited to be a part of the reform movement and make decisions that promote new classroom practices, or are they expected to be in response mode to yet another initiative?
 - External partners can add value to the district effort by providing professional development and serving as critical friends, offering constructive insights about programmatic directions and providing validation for “thinking outside the box.”
 - Community members and parents need to be informed about and understand the vision for science and language so there is a collective effort to support teachers as they are striving to improve their practice.
- **Developing trust between teachers and administrators** is an essential component for systemic reform and happens through ongoing communication, mutual support, and fostering a culture of experimentation and risk-taking.

- **The whole district needs to be invested as a learning community.**
 - Providing professional learning experiences is as important for district administrators (i.e., superintendents, assistant superintendents, principals, curriculum specialists) as for teachers.
 - Opportunities are provided for colleagues at all levels to learn together. A culture is created where experimentation and co-construction of ideas for developing high-quality learning experiences is valued.
 - Engaging teams of teachers and administrators in instructional rounds and observation protocols promotes thinking about instruction as an inquiry. Colleagues think together about a problem of practice, examine if newly adopted classroom practices are making a difference for the students, and propose next steps for moving the instructional practice forward.
- **Districts need to convey clear expectations** about science standards and communicate them in ways that teachers can understand and take up.
- **Districts must lead with the view that language development is rooted in building content understanding**, and that language use supports making meaning of content, particularly science.
- **Districts can benefit from creating pilot or “trailblazing” schools** where teachers are engaged in testing and refining new ideas and approaches and building up the resources before spreading to more schools across a district.
- **Capacity-building efforts to support shifts in instructional practice require a variety of resources**, including:
 - Ongoing opportunities for profession learning
 - Mechanisms for peer support, observation, reflection, and sharing
 - Support for teacher leadership opportunities
 - Careful planning for coherence of policy and professional learning experiences so that teachers’ growth is being supported and they do not feel like they are being asked to do something new all of the time
 - Providing and maintaining curriculum, hands-on materials, facilities for materials management, and support for curriculum modification by teachers
- Professional learning experiences need to be designed to build on the strengths and experiences of learners so that outcomes from the experiences can be leveraged across the district. Expect participation by all teachers within a district, but **develop programming that recognizes that “one size does not fit all.”**
- **Administrators can feel supported through collaboration with professional developers and community partnerships.**
 - Close collaboration between professional developers and administrators makes it possible for professional learning to be designed to respond to the constraints and needs of teachers’ school and district contexts.
 - Administrators can also participate in professional development to engage as learners and join instructional rounds to observe how science is being taught in the classroom.
- **Assessment can be a productive tool for feedback for both student content understanding and shifts in classroom practice.** Different forms of assessment can be used for both summative and formative purposes. (For example, participants in instructional rounds can be given protocols to help focus on the development of talk strategies in classrooms over time.)

New Directions and Implications for Research

Participants offered research questions and recommendations designed to support future efforts to create professional learning experiences for science and language development.



In the final conference session, participants were divided into working groups to draft suggestions for research and practice that would advance the emerging field of professional learning that supports science as a context for English language development. Their work was guided by the following set of questions:

- What evidence would support the claim that science is a good context for acquiring language?
- What do we need to know about how language develops through science?
- What kind of tasks, activities, and professional learning experiences will ensure that language affordances are provided, and will lead to engagement with and communication of science ideas?

“There needs to be further work on how to systematically integrate science and language because even though they are described as complementary, we really don’t know enough about how to actually get them to work well together in practice.”

– Paula Hooper, Senior Science Educator/Learning Scientist, Institute for Inquiry, Exploratorium

Research recommendations fell into three categories: 1) identifying existing knowledge, 2) defining new research, and 3) identifying different research methods and the potential questions they could address. The research recommendations exemplified the potential for partnerships between researchers and practitioners to create research-practice agendas that are mutually beneficial. Research recommendations focused on what can be accomplished through short-term methodologies (i.e., literature reviews) and longer-term efforts such as case studies, design-based implementation research (DBIR), and longitudinal studies. DBIR was suggested as a particularly powerful form of research because it is iterative, collaborative, and can bring together researchers, professional learning practitioners, and teachers.

1. Identifying existing knowledge

Literature Reviews

- Meta-analysis of qualitative research can identify things that “we know,” and thus, don’t need to reinvent. For example:
 - Studies of discourse in science classrooms can establish whether correcting or recasting works better for oral vs. written language.
 - Studies of discourse during science activities can identify how exploratory talk vs. representational talk operates in students’ meaning-making.
 - Connections can be made between issues of engagement, interest, and motivation that students experience across spaces of their lives (home, school, after-school), which are often studied in informal science learning.
- Clarify terms (e.g., scaffolding, academic language, etc.) that are used to support both research and practice. What do these terms mean? How do they work in practice?

2. Defining new research

- Develop more extensive analysis and deeper understanding of why science taught under particular conditions can be a good context for supporting language development. What patterns emerge across multiple studies that help us identify the features that facilitate this happening?
- Determine how changes in teachers' understanding and classroom practice impact several factors: the level of student talk, students' understandings of science ideas, and the nature of students' language use.
- Develop a stronger understanding of the science content knowledge that teachers need in order to construct the kind of pedagogy that enables science learning to be a good context for language learning.
- Affirm what is understood about supporting transformative professional learning and apply it to professional learning for science and language development. For example, research could be designed to:
 - Examine responsiveness to teachers' needs in various professional learning contexts in order to enumerate a variety of successful professional learning models and approaches
 - Determine productive ways to include teachers in the design and implementation of professional learning and examine the impact of this process of inclusion
 - Engage in meaningful collaborations with teachers, researchers and scientists to understand the influence of these collaborations on teachers' learning
 - Determine what experiences of science learning for teachers will be most consequential for their students' science learning
 - Understand how teachers' understanding of the role of language in their own science learning affects their subsequent use of language in the classroom, and what impact this has on their students' language development
- Direct attention to assessments. New research can address questions like:
 - What should assessments based on the three dimensions of learning in the NGSS look like, and what do they tell us about language development?
 - What will an assessment look like that will address the overlap of science and language instruction and learning?

3. Identifying new research methods and the potential questions they could raise

Design-based Implementation Research (DBIR)

- Robust reform efforts require an understanding of what works in a large variety of classrooms and settings. DBIR can facilitate the study of professional learning programs at various scales of impact from one classroom to the district level.
- These example research questions for DBIR can help create research designs that address the potential benefits of a hybrid practice of science and language development, and the professional learning approaches needed to help enact it:
 - Is there a difference between the effectiveness of strategies in classrooms with native speakers and classrooms with only English language learners?
 - All students are acquiring the language of science. English language learners are also acquiring English as a second language. How can professional learning be designed to support teachers in coming to meet the needs of both populations of students?
 - What is the influence of dominant language speakers on quiet students' development of language in the classroom?
 - What is the role of everyday language in developing scientific understanding through inquiry?
 - What is the role of teacher science knowledge in implementing this type of instruction?

Case studies

- Case studies of experienced teachers can address claims about conditions under which the affordances of science for language development can be realized.
- A greater corpus of case studies would make it possible to look for trends that indicate factors influencing students' science learning, language learning, and dispositions towards both.

Longitudinal studies

- Examine the effect and impact of hybrid instruction on students' persistence in STEM fields.
- Examine how language is used at particular times in relationship to science learning.

Final Reflections

These reflections were shared by Kris Gutiérrez and Guadalupe Valdés at the close of the conference. To view a full transcription, visit www.exploratorium.edu/education/ifi/inquiry-and-eld.

“Some Musing Under Construction”

Kris Gutiérrez, Professor of Language, Literacy and Culture, University of California, Berkeley



“Language is the tool of tools. It is the most powerful tool that we have.”

- **Science and language are inextricably connected.** We can move beyond the view of bringing science *into* language or language *into* science, and understand that they are *mutually* constituted.
- **Notions about how people learn are fundamental to the work on science and language.** Everyday and scientific knowledge, as well as everyday and scientific language, come together as more than bridges to each other; they grow into one another for deep and consequential learning.
- **Standards such as NGSS are most productively seen as tools to be used.** The practices are not skills in isolation but tools to be used to accomplish goals.
- **Students benefit from socialization models of learning that take place in interactions between learners and speakers of the target language.** This provides multiple opportunities to elaborate and revise their understanding over time, and supports them in becoming proficient in different types of discourse practices (e.g., description, argumentation, etc.)
- **Shifting from student-centered to community-centered models of teaching** lets students participate actively along with teachers in creating new knowledge. In these settings, expertise is distributed and dynamic.
- **We need to challenge the notions of scaffolding as the end point that has already been defined by the adult. Teachers can approach scaffolding with a “light pedagogical touch,”** offering just enough necessary information to allow students to engage fully in an activity, rather than directing students to an answer.
- **Teacher learning can be re-imagined to design for possible futures, leverage new tools, and incorporating informal or playful forms of learning. Teacher learning is not a linear process.** There are too many factors involved for it to be dependent on no more than the progression of time or one facet of teaching.

“Four Issues”

Guadalupe Valdés, Bonnie Katz Tenenbaum Professor of Education, Stanford University



“So I want to leave you with the idea: beware of labels, particularly labels for learners, and understand that they may not be telling you anything.”

- **The kinds of experiences that students are given to engage in can promote rich discourse and language acquisition.** It matters what the task is and what you talk about. Certain tasks are better at promoting rich discourse than others. Students need to be engaged with something they know about, care about, and want to know more about. Interactional conversations are essential for the development of students’ understanding.
- **Motivating students to read and write plays a distinctly important role in engaging students with science ideas and developing literacy.**
- **Teachers can use reading to take advantage of students’ desires to learn** more about a particular topic. And what students read can spark their curiosity to pursue ideas further. By supporting students’ pursuit of their own interests, teachers can cultivate lifetime readers.
- **Writing can be motivated by students’ desire to communicate** about something they know or want to learn more about. Because in writing “language stands still,” students can revisit what they’ve written to reinforce their conceptual understanding and language learning, and teachers can use students’ writing to attend to developing language.
- **When language is written, you need to consider the purpose and the audience**—writing notes for yourself looks different than writing to communicate ideas to others. When learning to write for sharing, students need ample opportunities to develop their ideas. Then modeling written language and attending to language conventions can come in as needed.

- **First language can be a valuable asset for giving language learners access to meaning.** It's not possible to participate in science, or any topic, if you don't have access to meaning. Giving students an opportunity when necessary for "translanguaging" (the use of all the language resources that students bring with them, including allowing the use of their first language) supports them to move forward to engage with others about their ideas.
 - **When students are users of a language, why do we continue to call them language learners?** Our views about the way we measure English language development impact the way we currently label and classify language learners. How long is a learner a learner? Our current classifications do not take into account the effectiveness of students' use of English to convey their ideas. The term "learner" may not be an appropriate indication of what they can accomplish with language.
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Institute for Inquiry®
Exploratorium®
Pier 15, San Francisco, CA 94111
exploratorium.edu

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Contact us by email at ifi@exploratorium.edu

